FMI 3.0 - a major milestone for interoperability in system modeling and simulation

The Functional Mockup Interface (FMI) has proven itself as the most widely adopted format for system simulation model exchange and the de facto industry standard for model exchange and co-simulation. FMI version 3.0, now released by the Modelica Association, is a major milestone for the standard with new features that enable the use of FMI in important new use cases: advanced co-simulation, virtual Electronic Control Units (vECUs), the next generation of Digital Twins, and artificial intelligence applications.

FMI 2.0 has established itself as the most widely adopted format for model exchange and co-simulation since its creation as the result from the publicly funded MODELISAR project. The royalty-free nature of Modelica Association standards and availability of open-source and commercial solutions right from the first publication have contributed to its rapid and wide adoption across many industries: automotive, aerospace, industrial equipment, buildings, energy, manufacturing, and others. More than 170 tools officially support FMI, and many more in-house solutions are built on top of FMI. Its adoption is still increasing at a healthy pace.

The development of FMI 3.0 has been guided by the needs of new use cases, and the experience from current end users and developers. The rapid digitalization of the engineering development process, and the growing needs for collaboration between suppliers and OEMs require technical advances to FMI in order to continue the success story over the next decades. The major advances are the following:

- **Advanced Co-Simulation.** The success of FMI has made the demand for high-quality co-simulation much more obvious. Many of the new technical features in FMI 3.0 are needed to enable high-quality, robust co-simulation of complex models. The realm of the possible with co-simulation has grown significantly with FMI 3.0.
- **Virtual Electronic Control Units.** Digitalization of the development process is the ultimate goal to improve efficiency in product development, especially with embedded software. Virtual Electronic Control Units (vECUs) help to achieve that

for embedded software development. FMI 3.0 has many features to turn Functional Mock-Up Units (FMUs) compliant with FMI 3.0 into full-fledged vECUs.

- **Layered Standards.** FMI 3.0 has introduced "Layered Standards", which allow users to embed artifacts from other standards within the FMI container in a systematic way. This greatly improves standards interoperability in a meaningful way.

- **Next Generation Digital Twins.** FMI is a great format for system-level digital twins, executed in the cloud or at the edge. FMI 3.0 brings system simulation digital twins to the next level.

- **Artificial Intelligence Applications.** Machine Learning and other artificial intelligence techniques are popular for calibrating parameters of the models contained in Functional Mockup Units (FMUs), the models compliant to FMI. FMI 3.0 supports updating parameters much more efficiently than previous versions.

"FMI 3.0 is a major step forward to enable new use cases arising in system simulation and we hope to have addressed most of the major challenges we simulation engineers face today to improve simulation capabilities of our tool ecosystem: across tools, across teams, across companies, across industries." - Andreas Junghanns, FMI Project Leader, Senior Manager R&D, Synopsys.

"All contributors invested a lot in the development of FMI 3.0. This manifests their commitment to the interoperability of simulation tools. Especially the introduction of ports that allow physical and bus-like connectors, the support of new data types, or the introduction of clocks to handle and distribute events in an efficient way will improve the usability of FMI and allow new use-cases. That was worth all the effort!" - Torsten Blochwitz, FMI Deputy Project Leader, Manager Research & Innovation, ESI Group.

"Within Bosch, FMI is the preferred solution for model exchange and co-simulation on the system level. It is heavily used for collaborative model-based systems engineering both internally and with external partners. We at Bosch Research have actively contributed to the development of FMI 3.0, which will bring important improvements for existing use cases such as the creation of virtual ECUs, and enable new use cases such as the efficient training of AI models encapsulated as FMUs." - Christian Bertsch, Senior Project Manager, Bosch Research.

For those interested in the added technical features that FMI 3.0 vs. FMI 2.0, see the paper The Functional Mock-up Interface 3.0 - New Features Enabling New Applications presented at the Modelica Conference 2021.

About the Modelica Association

The Modelica Association (MA) is a non-profit organization incorporated in Sweden with the mission to develop open-access, royalty-free, coordinated standards for the development and verification of cyber-physical systems. The open and royalty-free nature of the standards supports a rich eco-system of open-source and commercial solutions. The MA projects provide open-source assets, compliance checkers, and infrastructure to simplify the process of standards adoption, all publicly available under the Modelica GitHub organization, and organizes regular open-access conferences, with all papers available on the Modelica website. The Modelica Association standards are endorsed and recommended by many professional societies in the modeling and systems engineering domain: Prostep IVIP, PDES, NAFEMS, and INCOSE.

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